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Determining the general circulation is a primary goal of oceanography, as is determining the roles of the ocean in climate. These goals are closely related because the large-scale, time-mean circulation, together with its seasonal and interannual variations, substantially governs the mass, heat and salt fluxes on the planetary scale. The developing Global Ocean Observing System has at its core the sustained collection of a diverse set of observations of the ocean, and their synthesis into maps of the three-dimensional velocity field and its associated transports of heat, salt and mass.

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Towards Improved Ocean State Estimation

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LONG-TERM GOALS

Determining the general circulation is a primary goal of oceanography, as is determining the roles of the ocean in climate. These goals are closely related because the large-scale, time-mean circulation, together with its seasonal and interannual variations, substantially governs the mass, heat and salt fluxes on the planetary scale. The developing Global Ocean Observing System has at its core the sustained collection of a diverse set of observations of the ocean, and their synthesis into maps of the three-dimensional velocity field and its associated transports of heat, salt and mass.

OBJECTIVES

The objective of this effort is to devise and produce empirical estimates of the large-scale velocity and its associated dynamic pressure field, over the full water column for the Atlantic Ocean using all of the observations available. To do this, the multivariate covariance functions for the ocean observations are required. It is the goal this effort to estimate those covariances using the output from an eddy-resolving ocean circulation model.

APPROACH

The final product of these efforts will be estimates of three-dimensional velocity fields and the distributions of mass, heat, and salt for the ocean. By using a partial set of dynamic constraints (e.g., interior geostrophy, conservation of mass, and no flow through topography), we can combine measurements of all the quantities to improve the circulation estimates without imposing all the constraints of a full dynamical model. We will make the estimates using the statistical techniques called objective mapping, which is based on the Gauss-Markov theorem.

At the heart of any statistical interpolation of the observations are the covariance functions that describe how the data related to each other in time and space. The focus of this work is to gain a better understanding of the multivariate covariance functions that apply to the observable ocean. Our approach is to use the output from state-of-the-art high-resolution ocean general circulation models to estimate these covariance functions. For this effort we are utilizing the output from the Parallel Ocean Program (POP) that is being at global 1/10˚ resolution on the Earth Simulator.

WORK COMPLETED

The work on this effort thus far has consisted of writing new diagnostic code to be inserted into the model simulations being performed on the Earth Simulator in Japan. To do this, the code was developed and is now being tested at the Los Alamos National Laboratory in collaboration with Frank Bryan (NCAR), Matthew Hecht (LANL), and Julie McClean (NPS). The PI spent one week at the Naval Postgraduate School in Monterey in the spring of 2003 working on the code with Julie and Frank (who was on sabbatical there from the NCAR).

RESULTS

Since work has only just begun on this project there are no clear results. However, as part of the initial work, output from previous high-resolution POP simulations was analyzed and found to yield reasonable results. Other lower-resolution model simulations were also analyzed and found to be deficient. This has made the path toward estimating the covariance functions clearer as it has removed any doubt that only eddy-resolving model simulations are useful, and time will not be wasted analyzing non-eddy resolving simulations.

IMPACT/APPLICATIONS

When the covariance functions are estimated and understood, they will find application in a wide variety of ocean in other data assimilation efforts such as Global Ocean Data Assimilation Experiment (GODEA), the Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS) and the Estimating the Circulation and Climate of the Ocean (ECCO) project. Additionally, the structures of the multivariate covariance functions may reveal interesting ocean dynamics that have not yet been seen.

RELATED PROJECTS

This work is closely related to an effort funded by the National Science Foundation, whose principal investigators are Breck Owens and Steven Jayne (WHOI), Bruce Cornuelle (Scripps), Bill Large (NCAR) and Jim McWilliams (UCLA). This effort is developing the objective mapping techniques that will be used to produce the final maps of velocity and pressure. The covariance functions estimated from this ONR funded effort will be utilized in that objective mapping effort.